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SOIL CONSERVATION AND AMERICAN AGRICULTURE

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Cover Photo: *Grass-backed terraces with tile outlets. Montgomery, Iowa, June 1981. (Photo, Tim McCabe, SCS; Courtesy, USDA, Soil Conservation Service).*

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Articles appearing in this journal are annotated and indexed in *Historical Abstracts* and *America: History and Life*. The journal is also indexed in AGRICOLA.

Foreword

From 1620 to 1860, erosion became a serious problem on many American farms. By 1750 erosion was visually evident in the worn-out fields, abandoned farms and muddy rivers. Only a few far-sighted and educated Americans, however, began to realize the grave consequences involved in their reckless exploitation of the land. Among these early conservationists were Jared Eliot (1685-1763), Samuel Dean (1733-1814), Solomon and William Drown (1753-1834), John Lorain (1764-1819), John Taylor (1753-1824) and Edmond Ruffin (1794-1864). These individuals were among the few who realized that ignorance and the lack of useful information influenced poor soil conservation practices. Unfortunately, for about the next one hundred and fifty years, the land resource base appeared to many to be inexhaustable. During this period, the process of man bringing the land to its knees continued to appear reasonable and economically beneficial. This outlook and practice was, in fact, damaging and shortsighted in terms of future generations of Americans. On April 27, 1935, a national policy of saving the soil as a basic resource was finally set forth, as Congress declared soil erosion a national menace in an act directing the U.S. Department of Agriculture to establish a Soil Conservation Service.

Today, the National Agricultural Library, with extensive holdings and access capabilities to various data bases such as *Agricultural On-Line Access, Commonwealth Agricultural Bureaux, Historical Abstracts*, and *America: History and Life*, is a major center for published information on soil conservation activities throughout the world.

This special issue of the *Journal of NAL Associates* brings together interesting and informative papers on the importance of soil conservation to agriculture.

Once again, I compliment the editorial staff of the Associates of NAL.

Richard A. Farley
Director, National
Agricultural Library

Introduction

The national commitment to soil and water conservation through legislation came rather late in our history. The Soil Conservation Act of 1935 declared soil erosion to be a "national menace" and established the Soil Conservation Service. The breadth of vision of the Service's first chief, Hugh Hammond Bennett, determined the scope of the present program. Bennett had been a soil surveyor and soil scientist in the Department of Agriculture. He had read the few publications that appeared in the early 20th century on the dangers of erosion. These, and the unabated soil erosion that he had seen on far too many acres of farmland convinced him to undertake a campaign for corrective action. As he explained to colleagues in letters, he began to set up a "howl" about soil conservation.

It seemed that the articles, speeches, and correspondence with agriculturalists had succeeded when $5 million of Public Works Administration funds were allocated for erosion control. The distressing news, to Bennett, was that the money would be spent exclusively for building terraces. That terraces were a vital element in soil conservation, he was well aware. But he was equally convinced that terraces were no panacea. Knowledge drawn from numerous disciplines should be merged into a conservation system tailored to each unique erosion problem. The erosion experiment stations authorized in 1929 were supplying some of the answers, but conservationists needed more research on various aspects of conservation problems and the means to fit them into a system that would allow the farmer or rancher to use the land without abusing it.

Bennett's persuasive arguments for a comprehensive soil conservation program led to the job of Director of the newly created Soil Erosion Service, the predecessor of the Soil Conservation Service. In his new capacity, Bennett

could ensure that the national conservation program would draw upon any science or technology that would benefit conservation. To the Service he brought agronomists, biologists, botanists, plant scientists, range scientists, foresters, soil scientists, engineers, geologists, hydrologists, climatologists, geographers, psychologists, economists, historians, and other social scientists.

This sketch of the history of the Soil Conservation Service is offered to explain why this issue of the journal includes articles on diverse topics--tillage methods, range conservation, plants used in conservation work, structural measures for erosion control, and current soil and water conservation problems.

Ralph J. McCracken heads the group responsible for monitoring the condition of soil and water resources and for making soil surveys. Stephen K. Salvo is head of one of the 23 centers throughout the county that select plants to be used in conservation work. Richard E. Highfill, Arnold D. King, and Donald T. Pendleton are the Service's National Headquarters specialists in their fields. These five individuals along with many others are responsible for assimilating information to be used in the conservation program--information developed in the Service and by scientists and technicians in Federal and state research agencies, universities, and private industry. Technical information also flows from the field offices to the National Headquarters. SCS people in field offices who discover promising conservation practices notify the specialists. Thus, knowledge gained through experience at one location can be transmitted through the National Headquarters and technical centers to other SCS field offices.

From the few simple answers to conservation problems in 1933, a system of specialists has evolved that gives each discipline a hearing on its solutions to problems and makes the new ideas and methods available to district conservationists in nearly 3,000 locations in the United States.

Thanks is due to James DeQuattro and Linda Younger of SCS for editing and preparation of the papers for publications.

Douglas Helms, Historian, Soil Conservation Service, Washington, D.C.

Soil Conservation and Soil Quality

By

RALPH J. McCRACKEN*

As man evolved from his nomadic hunting for food to sedentary pursuits such as tilling the soil and herding livestock, there were negative as well as positive aspects of man-soil relationships. In his widely known study of the relationships between past civilizations and the soils that sustained them, Walter C. Lowdermilk concluded that soil erosion, the resulting siltation of irrigation canals, overgrazing, and the misuse of soil and vegetation were major contributors to the decline and fall of at least eleven civilizations and empires over the past 7,000 years. Most of his examples were in the Middle East and North Africa.1/ The soil eroded despite the back-breaking efforts of farmers who built bench terraces, dredged canals, built levees, and hauled eroded soil from lower points back to the hillsides. Another researcher, Gerald W. Olson, presented evidence for excessive erosion and crop yield reduction as factors in the decline of the Mayan culture of Central America over 1,000 years ago.2/ Not all of early agriculturalists depleted their soil resources. Some soils in central Europe have been farmed without deterioration for centuries and yields have been rising steadily for more than 150 years.3/

In the United States, European settlers and pioneers found some soils with relatively high natural productivity and soils which could be made highly productive with addition of amendments and good management. Some fragile soils in the Northeast and Southeast could be farmed by periodically "resting" the

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fields. In areas of low rainfall, many of the soils were suitable for crop production by irrigation.

Settlers cleared the timber from many of the forested soils of the East and Southeast and mined the native nutrients. Many farmers then moved to other lands and repeated the process. However, the picture was not totally bleak. In the East some farmers built up the soils (Alfisols and Ultisols) to an equilibrium productivity by using manures, guano, and cover crops.

Highly fertile prairie soils (Mollisols) in U.S. heartland were generally cropped to corn, wheat, other grains, hay, and pasture crops. This native soil fertility of the prairies has sometimes been called "God's gift to the pioneers," and was drawn upon to build the great American cities of the Midwest and Great Plains.

Soil erosion had not been a significant national problem prior to World War I. In the Midwest, rotations of erosive crops with close-growing grain crops and legumes and the reliance on animal agriculture and animal power generally kept the soil in place and fertility in balance. Yield levels increased, though slowly. In the Great Plains, fallowing was used extensively. The marginal, drier land was left in grass. In the Southeast, gully erosion was a problem on some farms. Only level land was farmed intensively in most instances. "Worn-out" land was left to regenerate in a shifting cultivation pattern. Some rudimentary terracing, use of brush dams and other check dams, and gully-filling were practiced sporadically. Crop yields in the U.S., increased slightly between 1880 and 1915.4/

The World War I emphasis on production, the decrease in the supply of new land that extended into the 1920s, and the increased use of mechanical power

were the harbingers of future problems. During the twenties and thirties, erosion became a more serious, highly visible, and significant national problem. Tractor agriculture increased sharply; farm size increased. With higher prices in the early part of this period, many native grasslands in the Plains were cultivated for wheat production. This practice, together with the onset of drought in the 1930s and the existence of unprotected marginal croplands, created the "Dust Bowl" conditions. In the South, the financial inability of tenant farmers to move to new "unmined" areas or to establish extensive erosion control practices led to an increasing amount of land left unprotected from beating rains. Numerous ugly, deep gullies and increased sheet erosion, especially in the Piedmont and upper coastal plains resulted.

These developments focused national attention on soil erosion and led to the establishment of the Soil Conservation Service in 1935 under the dynamic and evangelistic leadership of Hugh Hammond Bennett. Through demonstration projects, and later soil conservation districts, SCS promoted terrace building, stripcropping, and grassed waterways for the humid areas of the country. In the Great Plains and other arid areas SCS advised stubble fallow, residue management, and other practices to control wind erosion. The period prior to World War II was also marked by significant shifts of drylands and desert to irrigated agriculture with the development of large dam and water projects in the West. The increases in overall agricultural productivity from 1915 to 1940 were modest, but larger than the increases between 1880 and 1915.5/

During and immediately after World War II, all-out production and large inputs of technology were emphasized, especially in the Midwest and Great Plains. Animal power disappeared from most fields. Tractors, tillage equipment, and the

size of farms increased. Inexpensive nitrogen fertilizer was applied at increasingly higher rates. Pesticide use increased. Greatly improved crop varieties were introduced. These developments resulted in marked increases in crop yields and general agricultural productivity.6/ Soybeans joined corn as a major row crop in the Midwest and South. The farming pattern became a bi-culture of corn and soybeans. Cotton acreage decreased in the Southeast to be replaced by trees and pasture on the slopes and by soybeans, corn, and wheat on level areas.

In the early 1970s, prices rose and export markets for commodities increased significantly. The phrase "fencerow to fencerow" too often accurately described the increased crop planting. Many soils susceptible to erosion because of slope and poor physical properties, and thus unsuited to intensive cultivation, were converted to intensively tilled cropland.

But this demand for farm products has now diminished. Concerns about soil erosion have increased.7/ Recently available data and analyses show that more than 5 billion tons of topsoil are being lost each year in the U.S. due to water and wind erosion, including nearly 2 billion tons of soil from croplands due to sheet and rill erosion.8/ Concern is growing that the rate of increase in agriculture productivity may level off or drop significantly if new technology is not developed and applied.9/ It also appears that our greater applications of agronomic technology have masked the negative impact of increased soil erosion on the capacity of our soils to produce.10/ Farmers using larger, heavier equipment find it increasingly difficult to use the terraces, contouring and stripcropping previously relied upon to hold our soils in place. The drive for increasing the production of commodities salable in the export market has

Annual Sheet and Rill Erosion in Excess of 5 Tons Per Acre from Cropland

Region and state	Cropland acreage	Acreage with excessive erosion	Percentage of cropland in region with excessive erosion
	(1,000 acres)	(1,000 acres)	
Pacific:			
Washington----	7,951	1,080	
Oregon--------	5,148	187	
California----	10,073	258	
	23,172	1,534	6.6
Mountain:			
Montana-------	15,355	564	
Idaho---------	6,290	937	
Wyoming-------	2,970	188	
Nevada--------	1,107	--	
Utah----------	1,815	21	
Colorado------	11,093	1,036	
Arizona-------	1,312	3	
New Mexico----	2,282	98	
	42,224	2,847	6.7
Northern Plains:			
North Dakota--	26,913	2,096	
South Dakota--	18,156	1,934	
Nebraska------	20,699	4,733	
Kansas--------	28,806	5,191	
	94,574	13,954	14.8
Southern Plains:			
Oklahoma------	11,783	2,451	
Texas---------	30,439	5,548	
	42,222	7,999	18.9
Lake States:			
Minnesota-----	22,916	2,322	
Wisconsin-----	11,741	2,312	
Michigan------	9,484	1,003	
	44,141	5,637	12.8
Corn Belt:			
Iowa----------	26,431	11,979	
Missouri------	14,573	6,905	
Illinois------	23,836	8,725	
Indiana-------	13,320	3,754	
Ohio----------	11,762	1,846	
	89,922	33,209	36.9
Delta:			
Arkansas------	7,990	3,017	
Mississippi---	7,302	3,786	
Louisiana-----	5,899	2,204	
	21,191	9,007	42.5
New England:			
Maine---------	907	166	
Vermont-------	597	58	
New York------	5,969	1,321	
New Hampshire-	273	16	
Massachusetts-	282	34	
Connecticut---	201	48	
Rhode Island--	30	7	
New Jersey----	777	307	
Delaware------	542	75	
Maryland------	1,677	532	
Pennsylvania--	5,661	1,640	
	16,916	4,204	24.9

Annual Sheet and Rill Erosion in Excess of 5 Tons Per Acre from Cropland--Continued

Region and state	Cropland acreage	Acreage with excessive erosion	Percentage of cropland in region with excessive erosion
	(1,000 acres)	(1,000 acres)	
Appalachian:			
West Virginia--	991	151	
Virginia-------	3,209	1,005	
Kentucky-------	5,428	1,890	
Tennessee------	4,928	2,728	
North Carolina-	6,197	2,347	
	20,753	8,121	39.1
Southeastern:			
Alabama--------	4,499	2,480	
Georgia--------	6,487	2,836	
South Carolina-	3,331	925	
Flordia--------	3,189	686	
	17,506	6,927	39.6
Other:			
Hawaii--------	293	110	
Caribbean-----	363	230	
	656	340	52.0
United States---	413,277	93,779	22.7

Source: Soil, Water, and Related Resources in the United States: Analysis of Resource Trends, 1980 Appraisal Part II (Washington, D.C.: U.S. Department of Agriculture, August 1981), pp. 60-61.

resulted in a large increase in erosion inducing row crops on sloping, fragile erosive soils. Therefore, the theater of greatest concern for erosion and loss of agricultural productivity has shifted from the Southern Great Plains "Dust Bowl" and the Southeast Piedmont and Coastal Plain to other theaters. There is continuing and growing concern for erosion in several areas but especially in the Corn Belt, the Lower Mississippi Valley, and the Palouse area of the Pacific Northwest. These areas constitute some of our most productive soils. Some erosion results from natural and geologic processes. Soils can be replenished by natural renewal processes through topsoil regeneration and the formation of new soil by the weathering of underlying parent material.

The soil building process on many soils will replace the annual loss of five tons of soil per acre to erosion. At this, or a lower rate, many soils can restore and maintain productivity. Based on this standard, the 1977 National Resources Inventory indicated that 37 percent of Corn Belt states cropland, 43 percent of Lower Mississippi Valley states cropland, and 40 percent of Southeast cropland is suffering excessive erosion. Nationwide, 23 percent of our cropland is eroding in excess of the tolerable limit. The SCS-conducted inventory revealed that 13 states account for 69 percent of the soil loss. These states, listed in order of severity of erosion, are Iowa, Illinois, Missouri, Texas, Kansas, Nebraska, Mississippi, Arkansas, Indiana, Louisiana, Georgia, Tennessee, and Oklahoma.11/

Conservation technology may be catching up with farming practices. The extent of conservation tillage, a soil- and energy-conserving practice that can be used with large equipment, has been increasing rapidly.12/ We now have much better data on the extent of our erosion problems and on the locations of

severely affected areas. The U.S. Department of Agriculture is using an accelerated program to quantitatively assess the impact of erosion on soils with differing properties. This program is also determining the relative sensitivity of different soils to erosion, especially as it relates to permanent productivity. Information from these sources will facilitate a more effective and critical problem-oriented conservation program.

FOOTNOTES

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2. Gerald W. Olson, Soils and the Environment (New York: Chapman and Hall, 1981), pp. 131-36.

3. Charles E. Kellogg, The Soil That Supports Us (New York: Macmillan Co., 1949).

4. Yao-chi Lu, Philip Cline, and Leroy Quance, Prospects for Productivity Growth in U.S. Agriculture, Agricultural Economic Report No. 435 (Washington, D.C.: U.S. Department of Agriculture, 1979), pp. 9-10.

5. Ibid., pp. 9-10.

6. Ibid., p. 10.

7. R. Neil Sampson, Farmland or Wasteland: A Time to Choose (Emmaus, Pennsylvania: Rodale Press, 1981), pp. 1-11, 110-32.

8. Appraisal 1980: Soil and Water Resources Conservation Act, Review Draft Part II (Washington, D.C.: U.S. Department of Agriculture, 1980), p. 101; Soil, Water, and Related Resources in the United States: Analysis of Resource Trends, 1980 Appraisal Part II (Washington, D.C.: U.S. Department of Agriculture, 1981), p. 49.

9. Lu, et al., pp. 31-35.

10. William D. Shrader and George W. Langdale, "Effect of Soil Erosion on Soil Productivity," Determinants of Soil Loss Tolerance (Madison, Wisconsin: American Society of Agronomy, 1982).

11. Soil, Water, and Related Resources, p. 60.

12. William E. Larson, "Protecting the Soil Resource Base," Journal of Soil and Water Conservation 36 (1981): 13-18.

Structural Measures for Erosion Control

By

RICHARD E. HIGHFILL*

Resource management systems including vegetative, management, and structural practices can be designed to be compatible with monocropping systems, rotations, and farming with large modern machinery. Water disposal practices such as waterways, underground outlets, and grade stabilization structures support the basic conservation system. Sediment trapping practices including filter strips and sediment basins can be used when necessary. Structural practices--those involving earthmoving and materials such as concrete and pipe--are the focus of this paper.

Both structural and vegetative conservation measures are usually necessary for effective erosion control. To be most effective, structural works must be installed first and the complementary vegetative and management practices added concurrently or later. The simplest practices should be used first. If they can do the job, they create fewer problems. For instance, contour stripcropping spreads and reduces the impact of flowing water, while terraces and grassed waterways concentrate water flow and magnify the impact by discharging concentrated streams of water.

Vegetative Measures

Use of vegetative measures is the first line of defense against erosion. Soil that is covered with vegetation, either living or dead, erodes very little.

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Most erosion on cropland occurs between harvest and reestablishment of the protective cover of the next crop. Vegetation may not be adequate for concentrated flow channels on steep or long slopes; these areas will require structural measures such as terraces. Conservation cropping systems, conservation tillage, contour farming, contour stripcropping, and conversion to pasture, range, or woodland can be used, depending on the erosion problem.

Management

Control of erosion on cropland normally requires several conservation practices combined with good farming techniques and management, which include proper methods of fertilizing, planting, rotating crops, and controlling pests. Success of many conservation practices depends on production of healthy and vigorous crops. For example, conservation tillage can be used only when adequate amounts of crop residues are available. Terraces work most effectively when residue mulch from conservation tillage is present to help reduce runoff and the sediment load. Good management is as important to soil and water conservation as it is to economic crop production.

Structural Measures

Structural conservation practices reduce erosion by handling runoff water in a nonerosive manner. Examples include reducing the degree and length of slope or providing a low-gradient watercourse, erosion-resistant flowpath, or area for seepage of surface water. To be effective, structural practices must control erosion, manage water, and be farmable. The farmer must carry out all the necessary operations in an efficient and timely manner. To function

Corrugated aluminum drop structure. 1981. (Photo, James Cooper, SCS; Courtesy, USDA, Soil Conservation Service).

Work Unit Conservationst, John Conroy, is talking to Gene Miller and his daughter, Marilyn, about the corn crop, which is part of the production on the 280-acre farm. All corn is contour planted with a well-established water disposal system, as shown by this properly maintained waterway. This is the principal waterway for the drainage area on this farm in Ogle County, Illinois, August 23, 1965. (Photo, Erwin W. Cole, SCS; Courtesy, USDA, Soil Conservation Service).

Narrow-base terrace planted in permanent cover of bromegrass and alfalfa. Minnehaha County, South Dakota. (Photo, B.C. McLean, SCS; Courtesy, USDA, Soil Conservation Service).

Grass backslope terrace. Avoca, Iowa, June 26, 1970. (Photo, Erwin W. Cole, SCS; Courtesy, USDA, Soil Conservation Service).

Parrellel Level Bench Terraces. Mills County, Iowa, June 5, 1972. (Photo, Lynn Betts, SCS; Courtesy, USDA, Soil Conservation Service).

efficiently, structural practices must be planned and applied as components of a complete water management system on a watershed or land treatment unit. Landforming--reshaping the land surface to change the rate and direction of flow of runoff water--is gaining acceptance as a conservation measure. It can be compatible with farm machinery operations and meet drainage and other water management needs of the crop. Landforming can control erosion by controlling the runoff water in each row.

Terraces

Terraces are one of the oldest and most common structural erosion control measures. Their use in agriculture dates back thousands of years. A terrace consists of an earth embankment, channel, or combination of ridge and channel constructed across the slope. Many types of terraces are in use today. The type of terrace and outlet selected should be the one best suited to the field, to the farmer's preference, to the crops he grows, and to the machinery he uses.

Terraces alone usually do not provide complete erosion control. An effective system requires tillage and management systems compatible with the farmin operations. Terraces require a complete water disposal system, which may consist of grassed waterways, underground outlets, and grade stabilization structures. If improved water quality is a goal, terraces may be needed all the way down the slope to the bottom of the field. Other elements of a complete system may include fences, access roads, and field borders.

It is desirable for the complete terrace system to be planned before any work begins, so that the farmer can install it over a period of several years, compatible with his cropping system, weather, and financing arrangements. The

system can be planned from a topographic map or by field inspection including laying out trial terraces. The farmer must be involved in the planning. If a topographic map is used, he can see how the layout will work. In some cases, key terraces can be staked out and he can farm the field in the same manner that will be required after the terraces are built. This permits changes and adjustments in the system without costly construction changes.

Terrace alignment and parallelism are two important factors in planning. Underground outlets permit more flexibility in alignment, because they can be placed where they will be most advantageous for grade control. The shorter the channel length, the more flexibility one has in designing the channel grade, because short channels allow for steeper grades without causing erosion. Landforming and the use of borrow material can help in the alignment. Procedures have been developed to estimate efficiency of farming operation for the various systems. SCS defines field efficiency as the ratio of time required to farm the field as planned to the time required to farm a half-mile-long rectangular field of the same acreage.

Proper terrace spacing and design ridges are important for efficiency in farming operations. A spacing interval should be selected that not only reduces the slope length enough to control erosion, but also allows efficient operation of machinery. Terrace ridge size has caused a lot of problems. We hear terms such as a four-row terrace or a six-row terrace, which means that the terrace ridge is built to accommodate four- or six-row equipment. The terms may be for the front, back, or both sides of the ridge. In some cases, the ridge is large and well-rounded enough to permit farm equipment to cross it. This type of terrace requires careful attention and regular maintenance.

Steep vegetated backslope terraces are generally used on slopes of more than 6 percent. Narrow-based terraces--with both sides of the ridge steep and vegetated but not farmed--are gaining in popularity. These terraces are economical to construct and eliminate the problems caused by farming the ridge, including the hazard of tractors or harvesters tipping over. On the other hand, narrow-based terraces do take some land out of production. Regardless of type, the ridge must not greatly hinder farming operations if the terrace system is to be accepted by farmers.

In some cases, topography makes terraces impractical and a different kind of structural control is needed. Water and sediment control basins can meet this need. A basin is formed by constructing a short earthen embarkment across the slope and minor watercourses. The basin is designed for a 10-year frequency storm. Underground or soil infiltration outlets are required. Basins are spaced approximately the same as terraces and are installed as part of a complete conservation system that reduces erosion rates to acceptable levels.

A terrace is something everyone can see and accept as an effective erosion control device. Terraces trap 60 to 98 percent of the sediment that moves into them. They also slow runoff. They are, however, a nuisance to the farmer who must maintain them and carry out his farming operations. Terraces cost money, the amount depending on the topography and the sophistication of the system. Despite these disadvantages, terraces will be accepted practices for the forseeable future. They can be designed to minimize the nuisance problem.

Outlets

Terrace systems require an outlet. The SCS standard for terraces provides

for three types of outlets: (1) surface, such as grassed waterways, meadows, or pastures; (2) underground, such as subsurface drains or underground outlets or other types of conduits; and (3) soil infiltration, which is used where the rainfall and soils are such that the runoff will seep into the soil.

Waterways have been the most common type of outlet, but the increase of monoculture farming and the widespread use of chemicals have led to a decline in their use. Waterways are difficult to maintain with extensive use of chemicals and they take land out of production. Underground outlets take not land out of production and provide more flexibility in terrace grade and alignment. In many cases, they improve subsurface drainage. Soil infiltration, where adapted, is a very desirable outlet. Flat channel terraces provide erosion control, and they have another advantage: the runoff water is stored in the soil can be used to increase crop production.

Grade stabilization structures can be used to control head cuts and gullies. They also provide a stable outlet for the water disposal system. These structures can normally be located where they will have little effect on farming operations. Maintenance must be timely and effective if structural practices are to do their job.

Sediment Trapping

There are two economical and widely used methods of removing sediment from water: filter strips and sediment basins.

A strip of grass or other herbacious vegetation, living or dead, can remove sediment and other pollutants from runoff. The strip slows runoff water, increases infiltration, and provides habitat for microorganisms. Filter strips used are primarily to keep pollutants from reaching streams and lakes.

Sediment basins trap and store waterborne sediment or debris. Sediment transported in water can be removed if the velocity of the water is reduced sufficiently to allow the particles to settle out. Largest particles settle quickly, but removal of very fine clay sediments may require months of very still water or chemical treatment. Sediment basins are designed to store the anticipated volume of sediment while maintaining their required trap efficiency. In some cases, sediment can be removed to restore the basin to its original effectiveness.

The basin must be shaped so that the inflow is hydrologically far enough from the outlet to allow time for the sediment to settle out. Baffles for this purpose can be added if necessary. Sediment basins are most efficient if they are maintained full of water. If this is not practical, the pool should be drained at a very slowly. Sediment basins can be expected to trap about 85 percent of the incoming sediment if the water storage is about 10 percent of the annual runoff from the drainage area. Studies have shown that the average trapping efficiency of properly designed sediment basins to be more than 90 percent.

Summary

Conservation practices protect the soil surface and collect and carry surface runoff water to a safe outlet at a nonerosive velocity. These practices are most effective when combined in a total system with conservation tillage, management practices, and necessary structural practices.

Good planning, important for any erosion control system, must consider the farmer's desires, crops, machinery, method of farming, and the need to make a

profit. Conservation systems can be installed that are compatible with modern farming methods. With good planning, design, installation, and maintenance, conservation practices are effective and do not interfere unnecessarily with modern farming methods.

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Conservation Tillage

By

ARNOLD D. KING*

Soil erosion remains a serious problem in many areas of the United States. Water erodes an estimated 4.7 billion tons of soil from cropland annually. Wind accounts for another 1.5 billion tons in the ten Great Plains States.1/ Steep slopes, erodible soils, intense rainfall, improper tillage methods, and other factors combine to cause erosion problems that should be treated with conservation measures.2/

One basic objective should be considered in all erosion control plans--leaving as much crop residue (stalks and leaves) as possible on the soil surface throughout the year. To accomplish this objective, a wide variety of conservation tillage systems are being applied in many areas of the country. These systems use vegetation to reduce soil erosion on cropland. Conservation tillage systems are designed to provide optimum protection from erosion. They are also designed to provide adequate weed control, a favorable environment for germination and seedling development, and efficient use of moisture. Conservation tillage began in the late 1930s, as a response to wind erosion during the Dust Bowl era. The dust storms brought the seriousness of soil erosion to public attention. Stubble mulching, a tillage system first used in the wheat-producing areas of the Great Plains, was an early forerunner of the practices currently

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used. The benefits of leaving residue on the soil surface have since been well established, and use of conservation tillage is spreading rapidly.

A big breakthrough came in the mid 1950s, with the use of the herbicide 2,4-D, which made it possible to kill spring weeds and plant without extensive plowing. This and later herbicides greatly expanded the potential of conservation tillage for saving soil, water, and energy.3/ Weed-control technology continues to advance, and it is reasonable to assume that selective herbicides may become available to control all vegetation except the crop being grown.

Geographic Distribution and Potential for Expansion

The acceptance of conservation tillage systems has been phenomenal during the past few years. A 1982 survey by No-Till Farmer estimates that more than 100 million acres will be farmed with some system of conservation tillage during 1982. The most erosion-retarding of these systems is no-till, in which seed is planted directly into sod with no plowing. According to the 1982 survey, no-till will be used on a record 10 million acres. No-till acreage increased 22 percent from 1980 to 1981 and is expected to increase 13 percent in 1982. In the last 10 years, no-till acreage has tripled and acreage in all conservation tillage systems has increased by 357 percent, with 9 percent increases in both 1980 and 1981.

American farmers plan to no-till more corn, soybeans, grain sorghum, and even cotton this year than ever before. The leading no-till states will be Kentucky and Illinois, followed by Iowa, Virginia, Nebraska, Indiana, Ohio, and Pennsylvania.4/

If the trend continues, by 1992 most of our major crops will be grown by conservation tillage methods and erosion will be significantly reduced. A recent study projected that approximately 95 percent of the small grains, corn, sorghum, and soybeans will be produced under conservation tillage by the year 2010. If these estimates are correct, U.S. agriculture in the 21st century will present a scene far different from the clean-plowed fields of the 20th century.5/

The potential for expansion of conservation tillage throughout the Nation is limited only by the cropland available for planting. These systems are now adapted to a broad range of soils and crops, and there are many promising approaches which could sharpen the trend toward no-till. As long as research in science and technology continues to improve the techniques already in use, tillage reduction is likely to continue.

Conservation tillage is not, however, a panacea for all of our cropland erosion problems. On some soils and on steep slopes, adequate erosion control may require additional practices--terraces, grassed waterways, or other structural measures singly or in some combination--along with reduced tillage. Some soils are so higly erodible that they should remain in--or be returned--a permanent cover of soil-protecting vegetation.

Crops Adaptable to Conservation Tillage

The suitability of conservation tillage for a given crop depends on adequate weed control and planting equipment. To produce high yields, excellent weed control and precision planting are necessary.

All of the major field crops are well adapted to conservation tillage. To a lesser degree, so are vegetables and other specialty crops. Private and public research has emphasized production systems for such crops as corn and soybeans; vegetable and specialty crop growers have a narrower selection of herbicides and equipment.

Corn leads the way in conversion to conservation tillage. Farmers use conservation tillage on 60 percent of the Nation's corn crop and half the soybean crop. In 1982, about 8.4 percent of the corn crop will be produced with no-till and about 25 percent of the double-cropped soybeans will be no-till planted into wheat stubble.

Corn and soybeans in rotation are ideally suited for no-till as well as other reduced tillage systems. This rotation has advantages over a continous monoculture of either crop; it interrupts the life cycles of pest organisms and may also have weed-control advantages.

In recent years, researchers have sought reliable herbicides to use with no-till culture systems for horticultural crops.6/ Potatoes are a good example. Inadequate moisture and erosion control are the two greatest problems associated with potato production in Maine. Over the past five years, studies indicate significant advantages for no-till planting of potatoes in rye sod.7/ In similar work on tomatoes, yields were significantly higher with no-till than with conventional tillage.8/

Crop Residue and Erosion Control

With the Universal Soil Loss Equation (USLE) average annual soil erosion can be predicted for various cropping management and systems on a given kind of

No-till soybeans in wheat stubble. Montgomery County, Kansas, July 25, 1979. (Photo Gene Alexander, SCS; Courtesy, USDA, Soil Conservation Service).

Larry Johnson of Carver County, Minnesota, plants in last year's corn residue, May 1979. (Photo Gene Alexander, SCS; Courtesy, USDA, Soil Conservation Service).

soil. The equation is also valuable in comparing the erosion-control benefits of alternative conservation practices. Experience with the USLE has confirmed that managing crop residues is the most important consideration in controlling sheet, rill, and wind erosion on cropland. During erosive rains or windstorms, erosion is proportional to residues on the soil surface.9/

Residues from the previous crop can be removed, left on the surface, fully or partially incorporated near the soil surface, or plowed under. Conservation tillage is based on leaving as much residue as practical on the soil surface year round. With an optimum amount of surface residue, erosion can be reduced 50 percent on almost any field and as much as 90 percent on some fields. Severely eroding fields can benefit dramatically. For example, on a conventionally tilled field eroding at an average annual rate of 25 tons per acre, conservation tillage could reduce the rate to less than 5 tons.

For some crops, such as corn cut for ensilage, a cover crop may be necessary to provide enough surface mulch for erosion protection. Cover crops may also be necessary for low-residue crops such as potatoes and cotton. These crops do not produce enough residue to protect the soil even if all residue is left on the soil surface after harvest.

Conclusions

The economic and environmental benefits of conservation tillage make its large-scale use highly probable. By inhibiting erosion, conservation tillage--particularly no-till--benefits water quality and reduces sedimentation. For these reasons, conservation tillage warrants support from individuals, public agencies, and other groups interested in conservation activities.

The economic benefits of conservation tillage are not always immediate. When farmers first begin no-tilling, the only economic benefit may be reduced fuel consumption. Subsequent years will yield additional benefits such as improved soil condition, increased yields, and more efficient use of labor.

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Plants for Conservation

By

STEPHEN K. SALVO*

Increased demands are being placed on our soil and water resources to provide food, fiber, energy, and other products. Today, even more than during the Dust Bowl days of the thirties, specialized plants are needed to control erosion and other conservation problems caused by improper land use and management.

Ushered in by floods and national economic depression, the 1930's were a decade of recurring drought, insect plagues, and dust storms in the Great Plains. In the heart of the Dust Bowl, no fewer than 352 days had severe dust storms over the 5-year period from 1933 to 1937.1/ These storms, more than any other single factor, awakened the public to the destructiveness of soil erosion.

Early Plant Materials Work

In September 1933 the Soil Erosion Service (SES) was established in the Department of the Interior. Nineteen months later the agency was transferred to the Department of Agriculture and renamed Soil Conservation Service (SCS). The early work of SES and SCS concentrated on demonstration projects in areas with severe erosion problems. Many severely eroded sites needed immediate action, and by June 1936 there were 147 demonstration projects in operation.2/

In the 1930s, however, adapted grasses and legumes were not readily available for the jobs to be done.3/ Commercially produced plants were limited

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in number and in range of adaptation. Before 1940, only one forage plant native to the western U.S. had been domesticated and commercially produced: slender wheatgrass.4/

Early SCS work with plant materials focused on the large-scale production of specialized plants that would grow on difficult sites and provide erosion-controlling ground cover. Staff members to handle this job were recruited from state agricultural experiment stations and from disciplines such as agronomy, horticulture, and soil science. By June 1936, SCS was operating 48 nurseries to keep up with the demand for seeds and plants.5/

Two major activities of the nurseries were the collection of native seeds and plants and the development of plant materials to meet local conservation needs. Dr. Franklin J. Crider was manager of the National Observational Nursery in Beltsville, Md. He directed the nursery staffs to "find the plant that can do an effective conservation job wherever the problem may be."6/ In his search for new plants, Dr. Crider made contacts in the United States and abroad that accelerated the flow of new plants and seeds into the nursery program.

Plant Materials Centers

In the 1940s, SCS began shifting its focus from demonstration projects to soil conservation districts, and the number of SCS nurseries declined. Only ten remained by June 1954. In the same year, the nurseries' objective was changed from large-scale production to systematic evaluation and selection of superior plants. SCS began encouraging commercial nurseries to produce seeds and plants of released varieties.

To emphasize the shift from large-scale production, the nurseries were

designated plant materials centers (PMCs) in 1956. There were 18 PMCs by June 1962 and 23 in 1981. The work of the PMCs is supported by federal and state research agencies through cooperative agreements and memorandums of understanding.7/

The selection process begins when an interagency group of specialists in several disciplines identifies and ranks specific conservation problems that vegetation could help solve. Seeds and plants are assembled and evaluated, and promising ones are increased for more thorough comparison. The best materials are then tested at locations other than the centers to study their growth and other performance characteristics under different soil and climatic conditions. Seed and plants are distributed to soil conservation districts and other state and federal agencies for trial plantings on farms, ranches, and other sites where performance under field conditions can be studied.

The centers also try to determine which cultural methods will be most successful in establishing and maintaining plantings. Plants and cultural methods that can solve a conservation problem in one area may not be effective in another area because of soil and climatic differences.

SCS, state agricultural experiment stations, and other agencies cooperatively release the proven superior varieties. The PMCs then furnish seeds and plants to conservation districts and state crop improvement associations, who arrange to produce enough material to supply commercial growers and nurseries. Through its field staff, SCS promotes the use of released varieties in local conservation programs.

Use of Released Varieties

In 1940, SCS formally released its first conservation plant for commercial

production, 'Vaughan' sideoats grama.8/ Since then, systematic assembly, evaluation, propagation, and dissemination of plants have led to the release of more than 200 varieties of native and introduced plants. Since 1975, about 9 varieties have been released each year.9/ The entire selection process generally takes about 7 to 10 years.

In 1980, more than 140 SCS-released varieties of grasses, legumes, woody plants, and forbs were in commercial production. Table 1 lists some of these plants and their major use. The listed plants have multiple uses and most were released in the last 15 years. One of them, 'Selection 75' kleingrass, has been seeded on more than 800,000 acres of pastureland and rangeland in Texas, controlling erosion and producing enough forage for 988 million pounds of beef valued at $593 million (calculated at 60¢/lb).

Since the release of 'Shoreline' common reed in 1978, its use in protecting watershed structures has accounted for more than $5 million of savings in construction costs. 'Emerald' crownvetch stabilizes and beautifies roadsides, mined land, and other areas susceptible to severe erosion. About 20,000 acres are planted to 'Emerald' each year.

The average annual production of commercial seed of 'Luna' pubescent wheatgrass is enough to seed 25,000 acres. 'Latar' orchardgrass and 'Manchar' smooth brome reduce erosion and improve forage production on more than 100,000 acres of pastureland.

The most recent SCS release is 'Aroostook' rye, selected by the Big Flats, N.Y., PMC from more than 800 plants. 'Aroostook' is a reliable winter cover crop for the cold soils of the Northeast. It was developed specifically to protect intensively cropped soils after the harvest of late-maturing crops such as potatoes, cabbage, and silage corn.

Examples of SCS release varieties of conservation plants

Release variety	Major use for--	Released by PMC in--
'Alamo" switchgrass	Inland shorelines and small earthen dams	Knox City, Tex.
'Appalow' sericea lespedeza	Mine spoil	Quicksand, Ky.
'Arnot' bristly locust	Mine spoil	Big Flats, N.Y.
'Blackwell' switchgrass	Pastureland and rangeland	Manhattan, Kan.
'Cape' American beachgrass	Sand dunes	Cape May, N.J.
'Chiwapa' Japanese millet	Habitat for migrating waterfowl	Coffeeville, Miss.
'Corto' Australian saltbush	Mine spoil	Tucson, Ariz.
'Critana' thickspike wheatgrass	Mine spoil	Bridger, Mont.
'Emerald' crownvetch	Critically eroding areas	Elsberry, Mo.
'Emerald Sea' shore juniper	Sand dunes	Cape May, N.J.
'Goshen' prairie sandreed	Mine spoil	Bridger, Mont.
'King Red' Russian-olive	Windbreaks and shelterbelts	Los Lunas, N.M.
'Latar' orchardgrass	Pastureland	Pullman, Wash., and Aberdeen, Idaho
'Lathco" flatpea	Mine spoil	Big Flats, N.Y.
'Luna' pubescent wheatgrass	Rangeland	Los Lunas, N.M.
'Manchar' smooth brome	Pastureland	Pullman, Wash., and Aberdeen, Idaho
'Rosana' western wheatgrass	Mine spoil	Bridger, Mont.
'Selection 75' kleingrass	Pastureland and rangeland	Knox City, Tex.
'Shoreline' common reed	Inland shorelines and small earthen dams	Knox City, Tex.
'Tioga' deertongue	Mine spoil	Big Flats, N.Y.
'Wytana' fourwing saltbush	Mine spoil	Bridger, Mont.

SCS Plant Materials Center at Bridger, Montana. One of 23 such centers. October 20, 1972. (Photo James C. Meshnick, SCS; Courtesy, USDA, Soil Conservation Service).

District Conservationist Wayne Nipple (left) and Dwight Layton (right) of Decker Coal Co. at formerly mined area that has been reshaped and revegetated. Decker, Montana, September 1979. (Photo John Massey, SCS; Courtesy, USDA, Soil Conservation Service).

Evaluation planting of American beachgrass, Japanese sedge, coastal and creeping prairie grasses for sand dune stabilization. Sussex County, Delaware, Spring 1966. (Photo Don Echuhart; Courtesy, USDA, Soil Conservation Service).

Reed Canarygrass spot sodded to protect dam from wave action. Ida Grove, Iowa, September 1950. (Photo George W. Harmon; Courtesy, USDA, Soil Conservation Service).

In 1980, more than 5.2 million pounds of seed, 7.4 million plants, and 3.6 million sprigs of SCS-released varieties were produced commercially. These materials have a total retail value estimated at almost $20 million. Most important, seeding or planting these materials at the recommended rates would provide conservation treatment on 1.6 million acres.

New Plants for Special Problems

The need for new conservation plants is increasing because of higher demands on our Nation's abundant but finite soil resources. More intensive land uses call for increased efforts to protect the environment as well as maintain the productivity of our agricultural lands. To find plants for meeting conservation needs, the PMCs and plant materials specialists are conducting special projects and conservation field trials on more than 2,000 collections of native and introduced plants.

Demands for coal have increased the acreage disturbed by mining. In 1978, 3.8 million acres in the United States needed reclamation. This amounts to an area almost twice the size of Yellowstone National Park. About 1.1 million acres of this area is abandoned coal mined land. 10/

Unreclaimed mine spoil can be highly susceptible to erosion. The sediment-laden runoff, which may contain toxic elements, can harm water quality. Revegetating spoil areas can be difficult, especially where the soil material is extremely acid or contains toxic elements. Although several varieties listed in table 1 are effective in revegetating spoil areas, new varieties are needed.

On cropland used for no-till production of low-residue crops such as soybeans, plants are needed that will minimize sheet and rill erosion. Some

no-till systems could benefit from shade-tolerant, low-growing perennials that will protect the soil without competing with the main crop. Also needed are cover crops that are tolerant of residues from herbicides applied the previous year as part of a conservation tillage system. Cold-hardy plants are needed for winter protection of cropland. In the Palouse area of Washington, for example, rainfall and rapid snowmelt on frozen bare ground are major causes of erosion.

Windbreaks have traditionally been used to control wind erosion on cropland, but trees take a relatively long time to grow to effective heights; they also take land out of production. Drought-resistant, faster-growing varieties of woody plants and tall-growing grasses are needed to reduce the area taken out of production, be effective sooner, allow more flexibility in farm operations, and even provide the farmer an economic return. Such windbreaks would be more acceptable to farmers in many areas.

The search also continues for plants to control erosion on pastureland and rangeland while improving the quantity and quality of forage. For example, adapted legumes are needed that would improve the fertility of soil for range or pasture grasses. Establishment techniques are needed for seeding native range and pasture grasses in low-rainfall areas.

Other needs for improved plant varieties include reducing erosion and sedimentation in urbanizing areas; stabilizing roadbanks, streambanks, pond and lake shorelines, and sand dunes; breaking down land-applied sewage wastes; reducing noise; producing large volumes of biomass for fuel conversion while protecting the soil from erosion; improving the effectiveness and efficiency of flood-control structures in upstream areas; improving wildlife habitat; and enhancing the beauty of the landscape.

In many areas of the Nation, intensive land use or improper management--or both--still threaten to reduce the productivity and quality of our soil, water, and related resources. Conservation measures applied in the Great Plains and humid farm areas during the 1930s significantly reduced erosion by water and wind, but those years should serve as reminders of our need for vigilance. One sign of that vigilance is the continuing search for new varieties of conservation plants.

FOOTNOTES

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Home, Home on the Range

By

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Rangeland is land on which the native vegetation is predominantly grasses, grass-like plants, forbs, or shrubs useful for grazing and browsing. It includes natural grasslands, savannas, shrublands, most deserts, tundra, alpine communities, coastal marshes, and wet meadows. Rangeland also includes lands revegetated naturally or artifically to provide a forage cover that is managed like native vegetation.1/

Rangeland plant communities are principally natural ecosystems. Species composition and production are the result of the interaction of natural phenomena including soil, climate, topography, fire, floods, insects and use by grazing and browsing animals. While brush control and other range improvement practices may be used periodically, rangelands are not routinely irrigated, fertilized, overseeded with legumes or winter annuals, mowed, sprayed, or mechanically harvested. Much rangeland, though certainly not all of it, is characterized by environmental factors that limit its use for intensive agricultural enterprises. It may be too steep, too shallow, too rocky, too dry, or wet.

Although range plants generally cannot be economically harvested by mechanical means, they are nonetheless vital to the health and welfare of the American people.

Fortunately, ruminant animals, both domestic and wild, are uniquely adapted to grazing and browsing range plants and transforming the vegetation into highly

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desirable products for man's consumption and enjoyment. Rangeland production systems are also highly energy efficient. Management of grazing and browsing animals requires very little fossil fuel. This attribute will, in all probability, become increasingly important in food and fiber production. In addition to red meat and natural fibers, rangelands and range livestock provide many other valuable products. Wildlife habitat, water, recreation opportunities, and many by-products of range animals are a few examples.

Extent and Occurrence

Rangeland occupies about 40 percent of the land area of the continental United States. Acreage figures are tenuous, primarily because of transitional ecotones between forest and rangeland, with characteristics of both types. Recent inventory data indicate there are about 853 million acres of rangeland in the U.S.2/ Half of this is federally owned. Over 99 percent of U.S. rangeland lies in the seventeen western states and Alaska. The principal ecosystems are the prairie and plains grasslands, sagebrush-grass, desert shrub, and southwestern shrubsteppe.3/

Historical Perspective on Range Productivity

Range literature is replete with glowing accounts of the bounteous U.S. rangelands as observed and documented by early explorers and settlers. Reference to "a sea of grass," "best pasturage in the world," "grass belly deep to a horse," "an unlimited supply of forage," and "sweet grass growing with great vigor," are quite common.4/ A stockman traveling through central Texas in 1867 described the country: "Grass was everywhere from 1 to 3 feet high and

Ferdinand V. Hayden's survey party found plenty of healthy rangelands in 1870 at Red Buttes, Natrona County, Wyoming. (Photo William Henry Jackson; Courtesy, Records of the Geological Survey, National Archives).

sometimes as high as a cow's back, not only the bottomlands, but also in places on the drier uplands."5/ According to the report, the ranges would have supported 300 head of cattle to the section (640 acres). This figure reflects the eternal optimism with which early stockmen viewed the luxuriant native grasses and is indicative of stocking rates at that time.

Unfortunately, there is little quantitative data to support these observations. Undoubtedly, the explorers and early settlers were overly optimistic concerning the number of animals the range could sustain. In just a few decades, many U.S. rangelands had been significantly depleted.6/ Changes in plant composition and vegetation structure were generally accompanied by lowered productivity and reduced nutritional value for livestock.

In 1897, H. L. Bentley, special agent in charge of a grass station at Abilene, Texas, reported on the forage conditions in twenty-three Texas counties. He reported that:

> "Every acre of grass was stocked beyond its fullest capacity. Thousands of cattle or sheep were crowded on the range where half the number was too many. The grasses were consumed; their very roots were trampled into the dust and destroyed, and every green thing was cut down so that it could neither ripen seed and thus perpetuate its kind, nor recover from the trampling and exposure of its roots to the air and sun. Weedy species which were present before, but which had been held in check by the luxuriance of the better dominant sorts, immediately increased in number. And the mesquite and cactus, both of which may be destroyed by fire, also grew in numbers and commenced to crowd out the grasses."7/

. . .

"The carrying capacity of the range has steadily decreased until it is an exceptional property that can carry one head of stock to 5 acres. Today, it requires at least 10 acres per head, and it is often considered not the best policy to put on more than 50 cows to the section . . . The experience of most stockmen of the Southwest has been alike. They have seen the range that originally might possibly have supported 500 cows to every 640 acres decrease in capacity to maintain stock until 10 to 12 acres to the cow is not an exceptional case, but the general rule."8/

Another rangeman, Jared Smith, wrote in 1895, "There has been much written in the last 10 years about the deterioration of the ranges. Cattlemen say that grasses are not what they used to be, that perennial species are disappearing, that their place is being taken by less nutritious annuals. This is true to a very marked degree in many sections of the country."9/

The lack of knowledge and the attitude of the early stockman concerning range grasses was sadly illustrated by a resolution passed, without a dissenting vote, at a meeting of stockmen in the mid-1890s. "Resolved, that none of us know, or care to know, anything about grasses, native or otherwise, outside of the fact that for the present there are lots of them, the best on record, and we are after getting the most out of them while they last."10/

Secretary of Agriculture Henry A. Wallace reported to the U.S. Senate in 1936 that "Forage depletion for the entire range area averages more than half." He estimated range depletion on the public domain and grazing districts to be

more than 67 percent, and about 50 percent on private, state, and Indian lands.11/ Dr. Leo B. Merrill analyzed the decline in range forage about 1950. He wrote, "The number of livestock which can be grazed on most Texas rangelands today is less than half the number carried in 1900. Although this decline has been at a slow average rate of approximately 1.5 animal units per section per year, it has been continuous and has resulted in a heavy reduction over a 50-year period."12/ In 1900, about 125 animal units per section were carried with little or no supplemental feed provided. By 1948, production had declined to such an extent that 32 animal units per section was considered to be a moderate stocking rate.

Current Range Condition and Trend

Many range scientists believe range deterioration reached an all-time low in the 1930s, that range condition has been improving in the U.S. for almost fifty years, and that rangelands are presently in their best condition during this century.13/ One method of adjudging the state of health of rangeland is the range condition concept.

Range condition is an ecological rating of the plant community. It expresses the relative degree to which the kinds and proportions of plants in the present plant community resemble that of the presumed climax plant community for the site. In other words, range condition indicates the degree of departure of the present vegetation from the natural potential for the site. Departure from climax may be induced by any number of causes, including grazing. These changes may either enhance or depreciate the value of the resultant vegetation for various uses. An abnormal amount of any species represents a change in condition. Thus, range condition provides a basis for explaining the effects of

Overgrazed range. Arabaca, Arizona, March 21, 1903. (Courtesy, Records of the Bureau of Agricultural Economics, National Archives).

Rangeland reseeded with native gresses -- bluestem, sideoats grama, and blue grama. Washington County, Kansas, October 26, 1977. (Photo Gene Alexander, SCS; Courtesy, USDA, Soil Conservation Service).

past management and for predicting the direction and extent of changes likely to occur in response to specific treatment or management.14/

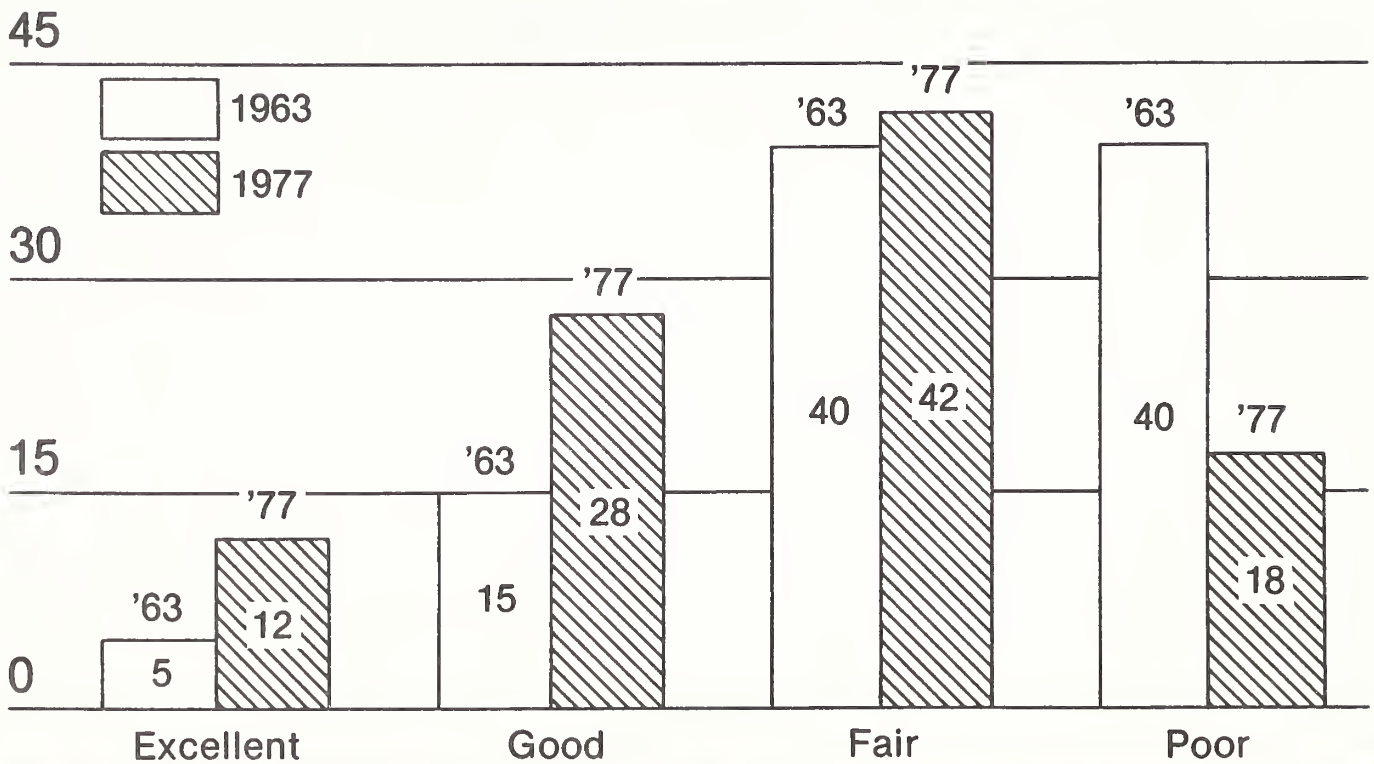
Four range condition classes are used to express the degree to which present plant composition resembles that of the climax. They are excellent, good, fair, and poor. Excellent condition means that over 75 percent of the present plant community is climax for the site; good condition, 51 to 75 percent is climax; fair, 26 to 50 percent. Poor condition indicates that 25 percent or less of present vegetation is climax for the site.

A 1977 study by the Soil Conservation Service indicated that 12 percent of nonfederal range was in excellent condition, 28 percent in good condition, 42 percent in fair condition, and 18 percent in poor condition.15/ This subjective judgment of range condition was compared with the results of a systematic sampling of range condition in conservation plans done by SCS in 1963. The comparison revealed that between 1963 and 1977, range condition improved markedly. Nationally, nonfederal rangeland estimated to be in excellent condition had increased 7 percent; that in good condition had increased 13 percent; that in fair condition had increased 2 percent; and rangeland in poor ecological condition had decreased 22 percent. In the seventeen western range states, condition had improved substantially in thirteen, remained more or less static in three, and had declined noticeably in one. The 1980 Assessment of the Forest and Range Land Situation in the United States estimated condition of all rangeland (Federal and nonfederal) in the contiguous States as follows: excellent, 15 percent; good, 31 percent; fair, 38 percent; and poor, 16 percent.16/

Outlook for Rangeland

The Resources Planning Act Assessment for 1980 predicted a net loss of

Figure 2. Percent of Non-Federal Rangeland by Condition Class - 1963 and 1977



55 million acres of rangeland by the year 2030.17/ Most of this loss would occur on privately owned lands. The prediction is supported by data generated by the Soil Conservation Service in their 1977 National Resources Inventory. We know, from the 1980 Soil and Water Resources Conservation Act Appraisal (RCA), that 39 million acres of nonfederal rangeland has a high or medium potential for conversion to cropland, and that 22 million acres of potential prime farmland is presently occupied by range vegetation and used for grazing.18/ Generally, the potential prime farmland lies in the Great Plains states where soil and climate are the most favorable for production of range forage as well as cultivated crops. In response to the growing worldwide demand for food crops, and in accordance with U.S. policy regarding agricultural exports, it is highly likely that most of these soils suitable for farming will be converted to cropland by 2030. The 1980 RCA Appraisal assumed that 36 million acres of our best rangeland would be lost to cultivation in the next 50 years.

If 1967-1975 trends were to continue, we could lose another 25 million acres of rangeland to other uses by 2030, mostly to water projects and urban expansion.19/ Losses of 55 to 60 million acres of rangeland could reduce the supply of range grazing an estimated 44 to 48 million animal unit months. Unless these losses are offset by increased production on the remaining rangeland, they could be particularly devastating because they would come at a time when the livestock industry is attempting to increase the proportion of red meat produced on grass and thereby reduce the length of the feedlot finishing period.

Present Production and Future Prospects for Range Productivity

Range productivity has always been and remains extremely variable over time and place. One expects this from such diverse ecosystems. Average annual

precipitation ranges from 5 to 55 inches; growing season, from 30 to 300 days; soils from a few inches to many feet deep; elevations from sea level to 10,000 feet. Production on range sites varies from less than 100 pounds of air dry vegetation per acre on some southwestern desert sites to more than 12,000 pounds per acre on some coastal marsh sites. Our studies of relict and well-managed areas also indicate that annual production may be 2 to 5 times greater in a favorable year than in an unfavorable year on the same site.20/

According to W. K. Lauenroth, North American grasslands are among the lower production classes in comparison to grasslands throughout the world.21/ Data from the International Biological Program indicate that average annual production on 40 percent of North American Grasslands does not exceed 200 grams per square meter. Seventy-five percent of the grassland area produces 300 grams per square meter, or less.

In the 1970s, U.S. ranges furnished 213 million animal unit months (AUMs) of grazing.22/ This is equivalent to 17 million animal units annually. It feeds about 40 percent of the U.S. beef cow herd and represents 15 percent of all livestock roughage. Almost 89 percent (190 million AUMs) of the total was produced on nonfederal rangeland. Although the contribution from Federal range seems small, it is very important to the range livestock industry and to the economy of local communities in areas of intermingled public and private lands. The 1980 Resources Planning Act Assessement projects an increase in the demand for range grazing from 213 million AUMs to 300 million AUMs by 2030.23/ Can U.S. ranges supply that amount of forage?

Most range scientists agree that range production can be increased significantly in the United States. They disagree considerably, however, when they

talk about the magnitude of the potential increase. Research has shown that about one-tenth of one percent of the energy received from the sun by the earth is fixed in photosynthesis.24/ C. Wayne Cook found range ecosystems to be more efficient, capturing somewhat less than 2 percent of solar energy.25/ If these estimates are reasonably close, there certainly seems to be room for increasing range production through plant improvement, vegetation composition, and more efficient harvesting (grazing) systems. Phenomenal increases in forage production as a result of range improvement are well documented. Five-fold increases, even ten-fold, are not uncommon. Yet, it seems unreasonable to expect that kind of increase over large areas. Present costs of improvements, soil and climatic limitations, and environmental concerns all constrain increased production through range improvement.

Several groups of experts have issued reports during the last decade on the potential productivity of rangeland. The USDA Interagency Work Group on Range Production, assembled in 1974, concluded that U.S. ranges could ultimately produce 1,700 million AUMs of grazing. That is over 8 times the current production and 4 to 5 times the projected demand. They cautioned that this level was not, however, a realistic measure of capacity because environmental impacts and trade-offs in competing land uses. The Work Group believed that intensive management of all available range could result in production of 566 million AUMs by the year 2000 and still meet other range use needs. This potential production is considerably more than the groups' prediction of demand for grazing--426 million AUMs per year. Such high production was contingent, they thought, upon "a normal climate, capital to invest in available improved range technology, recognition that grazing is compatible with other uses, and means for overcoming inertia."26/

Using the foregoing report as a base, the Resources Planning Act Assessment for 1980 also predicted that the nation's range has the physical capacity or biological potential to produce an estimated 566 million AUMs--more than 2.5 times the range production of the mid-1970s. This assessment indicated that this level was not attainable as a practical matter because much of the range is used for other purposes. Maximization of range grazing would adversely affect some of the related uses. The cost of producing at the biological potential level would probably double current costs and thus prompt a shift toward pasture and feed grains for meat production.27/

A 1981 study by Donald Hedrick and others held that the AUMs of range grazing could be increased to 620 million if all rangeland were improved to the "good condition" class. They put no time frame on their projection.28/

Less optimistically, and perhaps more realistically, many range scientists assert that production from U.S. rangeland can be doubled. Recent estimates indicate that over half of the U.S. nonfederal rangeland is in poor and fair condition. Ranges in poor and fair condition are generally producing at less than half of their potential. Following this line of reasoning and using 213 million AUMs as a base, we should be able to increase range production to 426 million AUMs. Note that no time limit is specified. We know that rangeland production can be increased substantially on a per acre basis. Yet, most of the higher predictions seem overly optimistic. They fail to consider the conversion of rangeland to other uses. They also fail to consider the physical deterioration that has occurred on many sites from erosion.

Many rangeland soils are shallow, steep, fragile, and susceptible to accelerated erosion when mismanaged. The rate and extent of erosion depends on

the kind and amount of protective plant cover and on the natural erodability of the soils. In the 1980 RCA, SCS adopted two tons of soil loss per acre per year as the maximum tolerable level of erosion on rangelands. At this rate, the range should remain economically and indefinitely productive. In 1977, ninety-five million acres of nonfederal rangeland had sheet and rill erosion in excess of two tons per acre per year. Fifty million acres were eroding at a rate in excess of five tons. Nationally, sheet and rill erosion on rangeland averaged 2.8 tons. Wind erosion was over two tons on another twenty-seven million acres in the ten Great Plains states. The average wind erosion rate on Great Plains range was 1.8 tons per acre. Ten of the seventeen western states had combined sheet, rill, and wind erosion rates of over two tons per acre.29/

Secretary of Agriculture Henry C. Wallace predicted in 1936 that it would take fifty years of careful management to restore the depeleted range to the extent that it could safely carry the 17.3 million livestock units (208 million AUMs) then grazing the range.30/ It is interesting to note that in the mid-1970s, only ten years ahead of the predicted time, U.S. ranges were supporting about 213 million AUMs, just five million over his prognosis. Secretary Wallace further predicted it would take 100 years to restore the depleted range to its "original grazing capacity." This, he estimated to be 22.5 million animal units or 270 million AUMs. According to some calculations, we can exceed the 270 million AUMs by 2030 only by applying some rather intensive management. Wallace's report has sometimes been accused of being unscientific. If it is unscientific, he certainly made some lucky guesses. His projections seem far closer than some of the recent, more optimistic estimates of potential production. Both the RPA Assessment and the RCA Appraisal for 1980 concluded that

range grazing in 2030 would be about the same as in the 1970s unless investments in range improvement are increased substantially above the current level. Current trends in range improvement through brush control, range seeding, and improved grazing management are expected to increase production. But this increase would be offset by the projected conversion of 55 to 65 million acres of our most productive rangeland to cropland and other uses..

The RCA projected production assumes that productivity per acre will increase at a rate of 1.1 percent per year due to technological advances. Of course, these assumptions refer primarily to cultivated crops. But if we assume that the increase in rangeland productivity due to technology will roughly parallel those in cultivated agriculture, we might expect around 328 million AUMs of range grazing by 2030. If this prediction is not correct, or if demand appreciably exceeds the medium predicted level--300 million AUMs--we might be hard pressed to meet the demand. To overcome the loss of range grazing due to land use conversions, to avoid a shortfall in range forage production by 2030, and to prevent degradation of the range resource could require some major breakthroughs in range technology, acceleration in the transfer of that technology, and tremendous outlay of capital for range improvement practices and programs.

In summary, there is both good news and bad. The good news is that we are blessed with an adequate base of productive rangeland, and that several technological developments have the potential to hasten range improvement. Grazing systems; more effective methods of brush management; more productive plants from introductions, native selections, and plant breeding; more effective use of prescribed burning; and new innovations in fence construction are a few practices that can increase range production, enhance harvest of range forage, and promote conservation of plant, soil, water, and animal resources.

The bad news is that capital for range improvements is currently in short supply. High interest rates force ranchers to postpone range improvements. Funds for research and for improving public rangelands are also tight in these austere times. And finally, technical assistance provided by Federal agencies to help landowners and users plan and apply range practices has suffered from the budget crunch. Because range improvement in arid and semiarid areas is a slow process, we cannot afford to wait to begin until the demand is upon us. We must be on with the job of range conservation and improvement--now.

FOOTNOTES

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3. Assessment of the Forest and Range Land Situation, pp. 48-49.

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16. Assessment of the Forest and Rnge Land Situation, p. 257.

17. Ibid., p. 32.

18. Soil, Water, and Related Resources, Part I, p. 63; Soil, Water, and Related Resources in the United States: Analysis of Resource Trends, 1980 Appraisal, Part II (Washington, D.C.: Soil Conservation Service, U.S. Department of Agriculture, August 1981), p. 63.

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20. Howard B. Passey, V. K. Hugie, E. W. Williams and D. E. Ball, Relationships Between Soil, Plant Community, and Climate on Rangelands of the Intermountain West (Washington, D.C.: Soil Conservation Service, U.S. Department of Agriculture, in press); Dennis F. Pendleton and George M. Van Dyne, Prediction of Grazing Land Productivity Under Climatic Variations, Progress Report No. 2 (Fort Collins: Colorado State University, 1980), pp. 10-15.

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26. Opportunities to Increase Red Meat Production, pp. 30-31.

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NEWS  NOTE

ASSOCIATES OF NAL ESTABLISH FUND FOR ACQUISITION OF RARE OR SPECIAL WORKS

At the annual meeting on July 23, The Associates of the National Agricultural Library voted to establish a fund for acquisition of rare and special works which will be given to the Library. For many years the Library has found that acquisitions funding was not available for very expensive works which could enhance the research value of existing collections. Desired works of historical, scientific, and often artistic value, which are scarce or rare, command high prices. Frequently, new publications are also high priced because of unusual characteristics of the publications or of the processes used in producing them. It is the objective of the Associates to raise funds to acquire such works and give them to the Library.

On July 23 The Associates also authorized the establishment of a fund-raising committee and charged the committee as its first project to raise funds to acquire the Banks' Florilegium. This work will eventually cost approximately $100,000, and is being published for the first time in 34 parts over a seven-year period from 1981 to 1987. It is the goal of the committee to raise enough funds to acquire the eight parts already published as soon as possible, and to guarantee a subscription to the remaining twenty-six parts. The committee also seeks to establish an additional reserve of funds which can be utilized for acquisition of other works as they are recommended and found worthy of Associates' sponsorship.

One-Hundredth Anniversary of the Bureau of Animal Industry -- Search for Information Services

The National Agricultural Library (NAL) has initiated a search of sources and an analysis of the documents, manuscripts, photographs and other illustrative material dealing with the former Bureau of Animal Industry (BAI) of the U.S. Department of Agriculture (USDA). This effort is being made in cooperation with a USDA Committee planning a celebration of the One-hundredth Anniversary of the founding of the BAI. The Committee consists of representatives of the USDA agencies that are continuing the functions and pursuing most of the goals of the BAI, including Agricultural Research Service; Animal and Plant Health Inspection Service, Veterinary Services; Food Safety Inspection Service, Meat and Poultry Inspection Operations; NAL; as well as the Historical Unit within the USDA's Economic Research Service.

In searching for material and information on sources of information about the BAI, the NAL Associates are being asked to cooperate by providing any material or information on the whereabouts of documents and memorabilia on BAI. Jesse Ostroff, NAL Technical Liaison Officer for Animal Science and Industry, is coordinating this effort and would appreciate any such information from the Associate membership.

Please write to: Jesse Ostroff, Technical Liaison
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